# STOCKBRIDGE BOWL WATERSHED ASSESSMENT

2014-04/604

PROJECT CONDUCTED 2015-2017

REPORT PREPARED BY:

TOWN OF STOCKBRIDGE AND BERKSHIRE REGIONAL PLANNING COMMISSION

PREPARED FOR:

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

BUREAU OF WATER RESOURCES

AND

U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION 1

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## *Executive Summary*

Stockbridge Bowl is listed as impaired in the *Massachusetts Year 2014 Integrated List of Waters* as impaired by Eurasian Water Milfoil (*M. Spicatum)* and by mercury in fish tissue. Thick macrophyte growth is especially notable in three areas of the lake: at the inlet to Lily Brook, near The Island, and in the outlet channel. The goal of the proposed Stockbridge Bowl Watershed Assessment Project was to identify the major contributing sources of sediment and organic material to Stockbridge Bowl from the subwatersheds of the lower, southern portion of the lake and the Lily Brook watershed, and to develop strategies to address these sources. Controlling sediment inputs to these will aid in the overall goal of reducing the prolific growth of exotic aquatic macrophytes, particularly *M. spicatum*.

The Town retained the consulting services of Inter-Fluve, Inc. (IFI), a professional firm specializing in geomorphology, stream restoration and lake management, to conduct the evaluation of the Stockbridge Bowl watershed. IFI was charged with conducting a watershed assessment of Stockbridge Bowl to address the influx of sediment entering the lake. From the outset of the project the assessment was designed to focus on the Lily Brook and Duck Pond Brook watersheds in particular to identify appropriate and cost-effective best management practices (BMPs) to reduce sediment loading into the lake. These areas of the lake have experienced accelerated sedimentation in recent years, providing the perfect medium for proliferation of Eurasian watermilfoil. IFI conducted the watershed assessment of Stockbridge Bowl using a combination of desktop analyses, which included GIS-based data sets and aerial photography sequences, and field reconnaissance.

IFI determined that sedimentation into Stockbridge Bowl is a natural process that should be expected due largely to the fact that the lake is a basin surrounded by relatively steep topography. The historical land use changes and lake alterations (dam construction, utility crossings, etc.) may have resulted in higher than background sediment loads and more sedimentation in the past. The watersheds appear to have mostly recovered and reforested. Many of the tributaries and drainage ways show signs of historical instability primarily related to watershed land use disturbance. Some of these channels may still be in the process of recovery. Dredging of the holding pond area and the shoal on the lakeside of the causeway are actions that will result in the most immediate tangible impact to the sedimentation in other areas of the lake. However, these dredging activities are more akin to a reset event or ‘surgery’ to treat the symptoms of long-term sediment delivery from the water-sheds of Marsh Brook and Lily Brook. This work would not eliminate sediment coming through the area, and some portion of sediment would still be routed through the holding pond. The other limitation with this project type is the need repeat the dredging program over time. Based on anecdotal accounts, prior dredging history and basic calculation completed for this study, dredging would may yield storage for 10 years or less of sediment emanating from these water-sheds.

IFI staff have suggested that implementation of focused erosion control activities at other sites within the Lily Brook watershed could yield incremental reductions in sediment loading to the lake.

IFI has informed local decision-makers that implementation of BMPs in these sites would not likely results in major shifts in sedimentation patterns and in fact may not yield measurable change. However, installing BMPs opportunistically, as part of a road improvement project for instance, could begin to address long-term sediment transport within this watershed. In an effort to mitigate sediment transport, the Stockbridge Bowl Committee chose three of the six high priority sites for which to pursue BMPs design. The Committee chose these sites out of the six priority sites based on the analyses provided to them in IFI's technical memos. Criteria used to choose the three BMP sites included relative potential for future erosion, site ownership, potential for implementation, and long-term maintenance burden. All three, being culvert projects on town-owned roads, could be conducted as part of larger road infrastructure improvement projects. The BMP conceptual designs for these sites are found in Appendix A.

The culvert retrofit and site-specific projects highlighted in the preceding section will not substantially reduce measurable sedimentation patterns in Stockbridge Bowl. They should be considered for opportunistic implementation as external funding becomes available or as part of the regular capitol program, but may be deferred in lieu of other activities if funding is limited. For these projects, the ratio of sedimentation reduction benefit to implementation cost could be low.

It would be prudent to first evaluate the contribution to the causeway shoal resulting from road sand application, and also from the relatively higher potential sediment yield north shore watersheds. This would include an initial program of sediment coring of the shoal on the lake side of the causeway, and possibly a follow-up engineering and hydraulic study. If the initial program concluded a plausible and likely contribution, then more in-depth evaluation of the actual watersheds along the north shore may lead to a more relevant, larger scale reduction program in those watersheds. The Scoping Outline developed as part of this project will guide next steps in this evaluation. The long-term benefit of this approach may exceed that gained from the relatively small-scale culvert retrofit projects drafted as part of this study.

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## *Introduction*

Stockbridge Bowl is listed as impaired in the *Massachusetts Year 2014 Integrated List of Waters* as impaired by Eurasian Water Milfoil (*M. Spicatum)* and by mercury in fish tissue. Thick macrophyte growth is especially notable in three areas of the lake: at the inlet to Lily Brook, near The Island, and in the outlet channel. Shallow warm water and soft soils provide the perfect growth media for thick vegetative growth in these areas, particularly the *M. Spicatum*. The prolific vegetation inhibits flow and facilitates the settling out of sediment and organic matter, perpetuating a cycle of ever shallower water levels in these areas. The *Stockbridge Bowl Lake & Watershed Management Plan* recommends three main actions: 1) attain a level of winter drawdown of up to six feet to control uncontrolled exotic plant growth, 2) install a diversion pipe underneath the gas pipeline that partially blocks the outlet channel to achieve the targeted drawdown level, and 3) dredge a few key areas around the lake to counteract sediment deposition and reduce the area of aquatic plant growth media. The Town of Stockbridge (the Town) and the Stockbridge Bowl Association (SBA) have both formally approved the recommended strategy of Drawdown, Diversion pipe and Dredging, which have been termed as the "3-D Program."

In 2012, at a project cost of $821,000, the Town and SBA completed the installation of the diversion pipe that will facilitate a deep drawdown of the lake. The installation was supported by a s.319 Nonpoint Source Pollution Grant of $245,500. As of 2017 the Town and SBA are in the midst of designing and permitting a dredging project that will remove more than 20,000 cubic yards of sediment upgradient of the diversion pipe to increase the pipe's efficiency. This second activity is also being supported with a grant from the s.319 grant program. With these actions underway, the Town and SBA decided to move upstream into targeted watersheds of the lake to identify the sources of accelerated sedimentation and mitigate problems at their source.

The goal of the proposed Stockbridge Bowl Watershed Assessment Project was to identify the major contributing sources of sediment and organic material to Stockbridge Bowl from the subwatersheds of the lower, southern portion of the lake and the Lily Brook watershed, and to develop strategies to address these sources. Controlling sediment inputs to these will aid in the overall goal of reducing the prolific growth of exotic aquatic macrophytes, particularly *M. spicatum*.

The Town of Stockbridge served as the project lead, with substantial support from the Stockbridge Bowl Association (SBA), an umbrella group of lake associations and major landowners within the watershed. Traditionally these two entities have partnered on lake management activities for Stockbridge Bowl, working in tandem to design, fund and oversee management of the lake.

## *Project Approach*

The project's overall objectives were to identify major contributing sources of sediment and begin to address those sources by developing conceptual BMP designs for two or three high priority sites. The proposed project consists of these five major tasks: 1) prepare a Quality Assurance Project Plan (QAPP) to guide analyses; 2) delineate subwatersheds in the project areas and create GIS-based analyses to estimate which sites are most likely to contribute significant sediment loading to the lower lake, conducting field work to verify delineations and identify probable sources of sediment; 3) conduct a Sediment Yield Analysis to estimate the sediment loads from land uses, streambank erosions and other probable contributors; 4) prepare conceptual level BMPs and cost estimates for up to three of the most significant contributors; and 5) engage residents within the targeted subwatersheds to aid in the identification and mitigation of sediment inputs and increase their awareness of nonpoint source pollution.

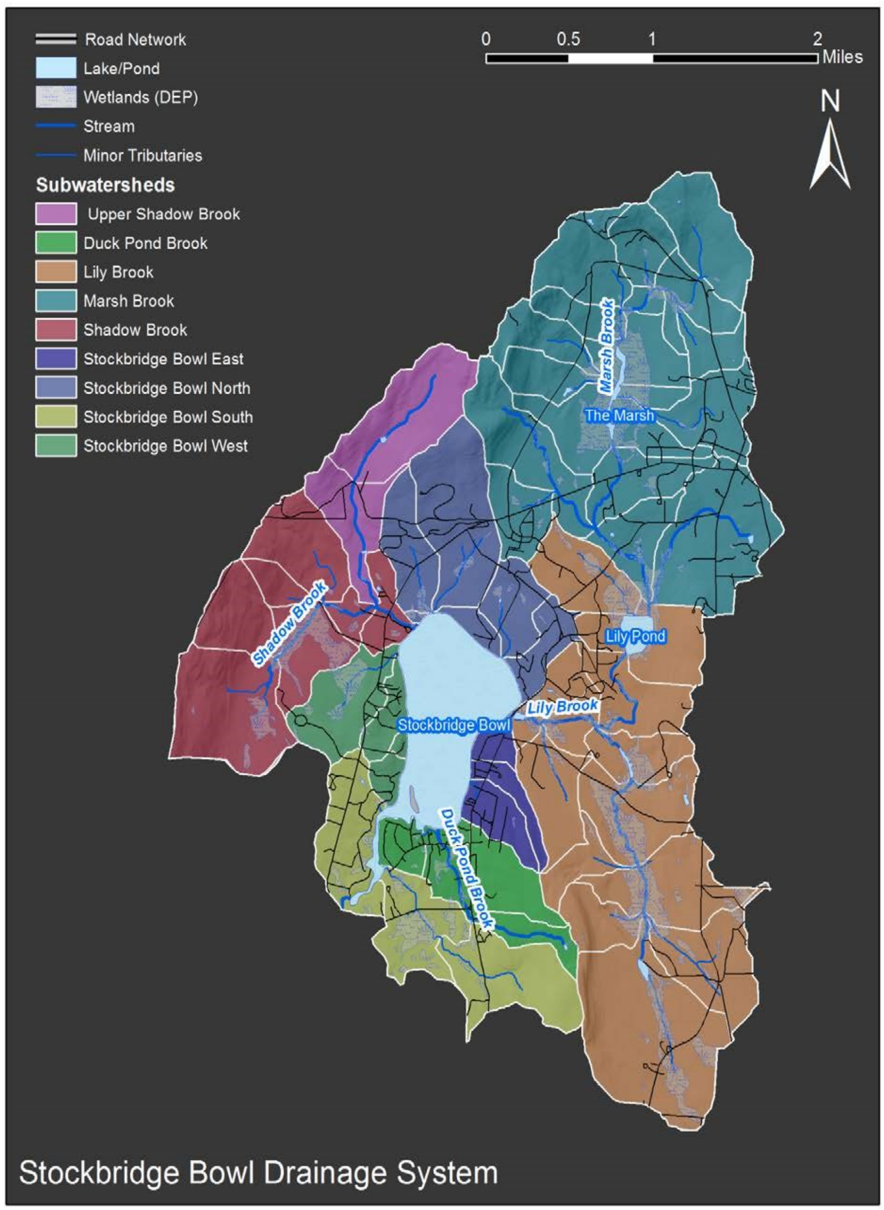
The Town retained the consulting services of Inter-Fluve, Inc. (IFI), a professional firm specializing in geomorphology, stream restoration and lake management, to conduct the evaluation of the Stockbridge Bowl watershed. IFI used a combination of GIS-based analyses and aerial imagery to identity sites that that may be unusual sources of sediment due to erosion because of land use, soil types, and/or topography. With this preliminary work in hand, IFI staff met with local residents and officials and conducted field reconnaissance to visit and evaluate potential sediment sources within the lake's watershed. For more detail refer to IFI's scope of work in Appendix A.

The Town served as the applicant for this proposal, with the SBA providing a substantial partnering role. The Stockbridge Bowl Committee, a committee comprised of representatives from the Town of Stockbridge (Select Board, Planning Board, Conservation Commission, Parks Commission, Public Works and Harbor Master) and SBA, served as the local advisory group for the watershed assessment project. The Berkshire Regional Planning Commission aided the Town in project administration, public outreach and reporting

## *Results*

IFI was charged with conducting a watershed assessment of Stockbridge Bowl to address the influx of sediment entering the lake. From the outset of the project the assessment was designed to focus on the Lily Brook and Duck Pond Brook watersheds in particular to identify appropriate and cost-effective best management practices (BMPs) to reduce sediment loading into the lake. These areas of the lake have experienced accelerated sedimentation in recent years, providing the perfect medium for proliferation of Eurasian watermilfoil. IFI conducted the watershed assessment of Stockbridge Bowl using a combination of desktop analyses, which included GIS-based data sets and aerial photography sequences, and field reconnaissance. The lake's watershed was divided into nine major watersheds, comprising of 58 smaller watersheds, including the lake water body itself. The initial results of this work indicated that watersheds north of Stockbridge Bowl may be more likely to deliver sediment to the lake, as the soils are more erodible, the landscape is steeper, and there are more disturbed forest areas. Guided by the initial desktop analyses and discussions with local residents, a watershed and channel reconnaissance was conducted, focusing in particular on areas believed to be feeding water and sediment to the northeastern and southern portions of the lake. A review of the tributaries and road crossings in the Duck Pond and Lily Brook watersheds was conducted in order to ground truth suspected sources of sediment. Local residents familiar with the lake hosted IFI staff along a shoreline survey from a pontoon boat and then guided staff to sites of specific interest in the lake and on land. IFI staff further conducted field work on their own in wetlands and stream channels, gathering field data to evaluate and quantify potential sediment transport volumes.

As a result of this work, several sites within the Stockbridge Bowl watershed were identified as areas of erosion and potential sediment transport, including road crossings, residential properties and the Lily Brook Basin. Fourteen sites were listed for their relative potential for future erosion and sediment yields, forming the first list of potential sites for future remediation and BMP implementation. The full analyses and discussion of findings are found in the *Task 2 Summary: Desktop Analysis and Field Reconnaissance* (Appendix A).



Following initial analyses, IFI conducted a series of GIS-based desktop sediment yield calculations for the nine major Stockbridge Bowl watersheds. IFI determined that sedimentation into Stockbridge Bowl is a natural process that should be expected due largely to the fact that the lake is a basin surrounded by relatively steep topography. The historical land use changes and lake alterations (dam construction, utility crossings, etc.) may have resulted in higher than background sediment loads and more sedimentation in the past. The watersheds appear to have mostly recovered and reforested. Many of the tributaries and drainage ways show signs of historical instability primarily related to watershed land use disturbance. Some of these channels may still be in the process of recovery.

While the Marsh Brook watershed was found to be the largest potential source of sediment to the lake, it is unlikely that sediment from this watershed contributes substantially to the total sediment load of the lake due to deposition in the extensive Marsh Brook wetland complex and Lily Pond and its adjacent wetlands.

The second largest potential source of sediment is Lily Brook. Although much of the sediment is predicted to emanate from the upper reach of the watershed, substantial sediment deposition is likely retained by Lily Brook wetland complex. However, anecdotal and field observations suggest that some proportion of the fine sediment and organics are routed through the wetland and holding pond area upstream of the Mahkeenac Lake Road causeway. The sedimentation that has occurred in the lake and holding pond area near the outlet of the Lily Brook watershed is likely attributable to overlapping processes and may be sourced from multiple locations in the Stockbridge Bowl watershed. This area was likely first impacted by management of the lake outlet, which may have led to more persistent backwatering of the lower Lily Brook drainage by maintaining lake levels that were elevated relative to historical conditions. This would have enhanced sediment accumulation in the lower watershed and may have enhanced development of wetlands in the area.

Construction of the causeway for Mahkeenac Lake Road likely further enhanced sediment deposition on its upstream side, acting as a dam allowing sediment-laden storm flows to be partially stored, causing some of the sediment to settle out of suspension and transport. The sedimentation in the holding pond area had been managed proactively through the early 1970s, but by the 1990s the holding pond had predominantly filled again to the extent that sediment-laden water could be observed being routed through the pond. Although no sediment cores from the holding pond were available for this study, the sediment stored there is sourced from the Lily Brook watershed, and is presumed to include predominantly fine soils and organics, mixed with smaller proportions of sand.

Dredging of the holding pond area and the shoal on the lakeside of the causeway are actions that will result in the most immediate tangible impact to the sedimentation in other areas of the lake.

However, these dredging activities are more akin to a reset event or 'surgery' to treat the symptoms of long-term sediment delivery from the watersheds of Marsh Brook and Lily Brook. This work would not eliminate sediment coming through the area, and some portion of sediment would still be routed through the holding pond. The other limitation with this project type is the need repeat the dredging program over time. Based on anecdotal accounts, prior dredging history and basic calculation completed for this study, dredging may yield storage for 10 years or less of sediment emanating from these water-sheds.

The third area of potential sediment transport is the Stockbridge Bowl North watershed, which includes several direct outlets to the lake. Fluvial fan-shaped deltas of sand and small gravels are found at the mouths of these streams. While the coarse material may be remobilized short distances in large flow events, it is notable that the fine sediment and organic matter generated within the tributaries are not likely deposited at the lake confluences but continue in transport into the lake to secondary deposition locations.

The general shape of the sediment deposits on the lake side of Mahkeenac Lake Road is not specifically of a fan, but more similar to a lakeside shoal. The deposit is in a natural shoaling location in the lake, in a shallow embayment downwind of the prevailing wind direction and of multiple tributary deltas along the north shore of the lake. While it is not possible to definitively conclude based on the current data, there is a notable likelihood that some of the shoaling in the sediment deposit in the shallow embayment adjacent to the causeway originates from the watersheds on the north and northeastern margins of the lake. It should also be noted that future enhanced seasonal drawdowns may result in some remobilization of sediment stored in the holding pond and adjacent wetlands, and also from shoals along the lake margin. See *Task 3 Summary: Sediment Yield Modeling and Project Concepts* for the full discussion of findings and the presentation made to the Stockbridge Bowl Committee (found in Appendix A).

A major goal of the assessment project was to identify sources of sediment and develop conceptual designs for two-to-three sites to mitigate sediment transport to Stockbridge Bowl. A result of these findings yielded a list of six priority locations within the Lily Brook watershed where past and potential future erosion are sediment sources. Taking into consideration all of the analyses, IFI has determined that the action that would yield the greatest measurable reduction in sediment loading into the lake would be to dredge built-up sediment in the holding pond, which allows fines into the lake during storm events. However, further study is needed to more clearly determine sediment inputs from the various tributaries in the north/northeastern area of the lake before any remediation activities are attempted at this site. IFI has provided a *Scoping Outline for Future Studies* to guide decision-makers in taking the next steps to address the sedimentation of the Lily Brook wetland and the associated shoal on the lake side of Mahkeenac Road. This memo is found in Appendix A.

IFI staff have suggested that implementation of focused erosion control activities at other sites within the Lily Brook watershed could yield incremental reductions in sediment loading to the lake. IFI has informed local decision-makers that implementation of BMPs in these sites would not likely results in major shifts in sedimentation patterns and in fact may not yield measurable change. However, installing BMPs opportunistically, as part of a road improvement project for instance, could begin to address long-term sediment transport within this watershed. In an effort to mitigate sediment transport, the Stockbridge Bowl Committee chose three of the six high priority sites for which to pursue BMPs design. The Committee chose these sites out of the six priority sites based on the analyses provided to them in IFI's technical memos. Criteria used to choose the three BMP sites included relative potential for future erosion, site ownership, potential for implementation, and long-term maintenance burden. All three, being culvert projects on town-owned roads, could be conducted as part of larger road infrastructure improvement projects. The BMP conceptual designs for these sites are found in Appendix A.

IFI also stressed the continued need to consider the causal end of the spectrum which would include: 1) an education and outreach campaign in the Lily Brook and Marsh Brook watersheds, visiting with individual landowners throughout the watersheds, assessing their properties on a case by case basis, which may result in projects like buffer strips or small drainage improvements on individual parcels, 2) a more in-depth look at the road sand program particularly on the east and north margins of the lake, and possibly helping to devise ways to mitigate its effects, and 3) a more in-depth look at the ability for fine and organic sediment to be transported from the north shore watersheds to the shoal on the lake side of the causeway. This will involve continued public involvement.

## *Public Involvement*

Involving residents, officials and lakeside property owners was important to this project for several reasons. Initially, having residents and other stakeholders attend field work and provide on-the-ground assistance is not only key to verifying suspected sediment sources, but also to ensure that consultant staff investigate sources that may be hidden from computer modeling processes. Involving stakeholders also increases their understanding of non-point source pollution and possible sources so that they will be better prepared to make science-based decisions when considering future improvement projects within the lake's watershed. Although lake residents often educate themselves about in-lake ecology (e.g. water clarity, nutrient enrichment, aquatic plant biology) and in-lake management techniques (e.g. drawdown, weed harvesting, herbicides), it is less often that they track sources of impairment upstream into the lake's watershed. This assessment project provided the opportunity for stakeholders to learn the basic concepts of geomorphology, and how factors such land use, soil type, slope, vegetative cover, wetland attenuation and flushing rates act in concert to influence erosion rates and sediment transport. For example, residents have for years been concerned that tree clearing for residential lawn expansion within the Lily Pond Brook watershed was a major source of runoff and sediment to Lily Brook. However, field reconnaissance of Lily Brook below Lily Pond indicated that this was not the case, as ground vegetation had been maintained, especially along riparian corridors. IFI found that water clarity was good, the stream channel showed no signs of erosion or mass wasting, and the stream's floodplain was intact, indicating that unusual erosion and sediment transport above this stretch of stream was unlikely outside of severe storm events.

A shoreline survey of the lake conducted in 2012 indicated that there were a few key sites within the watershed of Stockbridge Bowl that were chronic sources of sediment, but that overall the largely undeveloped nature of the watershed limited erosion and sedimentation rates to what would be occurring naturally in the watershed. It was suspected that those tributaries that were sources of greater sedimentation was due to soil type and steep slopes. The results of the GIS modeling and the field reconnaissance with IFI staff verify those suspicions, revealing that sediment transport to the lake is most likely occurring due to flushing of sediments stored in ponds, wetlands and pooled areas of tributary streams during severe storm events.

Although the Town and SBA have commissioned several studies and conducted in-lake management projects over a span of more than two decades, the results of this work were largely unknown to the general public. The watershed assessment project became the second of three DEP-funded, Clean Water Act projects, and updates given through newsletters and Selectmen's meetings has created a greater public interest in lake management issues. As a result in 2016 the Stockbridge Bowl Committee was formed, with the goal of creating greater communications and efficiency between the various lake stakeholder groups and local year-round residents. This new committee creates a more inclusive roundtable of lake interests, particularly town boards that had previously only been marginally aware of in-lake projects. The Committee's membership includes representatives of:

- Stockbridge Select Board (CEO, permitting authority)
- Stockbridge Conservation Commission (permitting authority, landowner)
- Stockbridge Public Works (public works, weed harvester)
- Stockbridge Parks Committee (town beach)
- Stockbridge Bowl Harbor Master (boating, boat launch monitoring, dam and water level authority)
- Stockbridge Bowl Assoc. (umbrella organization of several lake associations and large landowners, major lake management partner with town, major fundraiser)

## *Lessons Learned*

The Town of Stockbridge (pop. ~2,000) embarked upon this watershed assessment at the same time in which it was designing a multi-million dollar lake management project. That project involves the design and creation of an inlake channel to allow the full functionality of a diversion pipe that was installed in 2012. The fundraising and oversight of that project is being conducted jointly by the Town and the SBA. The partnering entities had successfully overseen the installation of the diversion pipe project and were ready to tackle additional lake management projects. Because sediment build up provides the perfect growth median for Eurasian watermilfoil and is the reason that an inlake channel needs to be created, the Town and SBA believed it was necessary to identify and address sources of sediment input. The Town therefore applied for grant funding to the DEP 604b program and to the s.319 program in the same fiscal year as part of a long-term watershed / lake management strategy. Conducting both the in-lake project and the watershed assessment at the same time seemed like complementary activities.

However, the inlake channel project, which was complex on its own, became additionally complex due to the presence of rare species, incurring cost and time overruns. A contract dispute between the Town and the engineering firm culminated in a months-long legal negotiation that set the project back even further. At the same time the government of the Town of Stockbridge underwent a transformation due to the retirement of the town's long-serving town administrator and the retirement of a key member of the Select Board. As a result, the inlake channel project inordinately consumed all the time and capacity of the town officials and SBA volunteers that were overseeing the project. They had little time to devote to the watershed assessment project being conducted concurrently.

IFI presented the findings of their analyses to the Stockbridge Bowl Committee in the fall of 2016. Although they had indicated during their presentation that sediment transport into Stockbridge Bowl is largely due to natural processes, they never at that time indicated that pursuit of BMP mitigation at sites within the Lily Brook watershed would yield very limited overall benefits. They did not effectively communicate that pursuit of other analyses or studies (such as focusing more intently on the sediment make-up of the shoal or on investigating the origins of sediment from the northern watersheds could be contributing to the shoal) would have been more beneficial than development of BMPs at specific sites. Instead they allowed local decision-makers to go through the process of selecting the top three priority sites (out of the list of 14 sites) for which BMP conceptual designs would be developed. It was during the drafting of engineering designs, when the Town was requesting BMP design levels of 30% completion, that IFI staff made clear their strong opinion that implementation of the BMPs would yield little overall sediment reduction to the lake. IFI stated at this time that the benefit-to-cost ratio would be extremely low, and that the BMPs should only be pursued if the Town were considering infrastructure improvements along the roadways on which the BMPs were located. Had IFI clearly and earlier communicated its opinion that BMP implementation would yield such limited benefits, the Town of Stockbridge may have had time to amend Task 4 of the scope of work to redirected engineering funds away from BMP design and towards further evaluation of input to the inlake shoal.

Although the Town did not receive engineering designs to a 30% design level, IFI did provide additional design details and drafted a *Scoping Outline for Future Studies* that will guide the Town and the SBA in further evaluation of the shoal in the northeastern cove.

## *Conclusions / Project Summary*

Stockbridge Bowl is a basin surrounded by relatively steep watersheds, and lake sedimentation is a natural process that should be expected, especially due to organic sediment and debris. Historical land use changes and lake alterations (dam construction, utility crossings, etc.) may have resulted in higher than background sediment loads and more sedimentation in the past. The watersheds appear to have mostly recovered and reforested. Many of the tributaries and drainage ways show signs of historical instability primarily related to watershed land use disturbance. Some of these may still be in the process of recovery.

With respect to the generation of sediment in source areas that leads to sedimentation in the holding pond area, no acute erosion sites were located within the watersheds that would largely explain the sediment accumulation. The sources of the sediment that has accumulated in the holding pond and on the lakeside of the causeway is likely due to contributions highly distributed throughout these watersheds, and also from the watersheds along the north shore (in the case of the lake side shoal). This pattern is consistent with expectations for a lake surrounded by relatively steep watersheds.

The culvert retrofit and site-specific projects highlighted in the preceding section will not substantially reduce measurable sedimentation patterns in Stockbridge Bowl. They should be considered for opportunistic implementation as external funding becomes available or as part of the regular capitol program, but may be deferred in lieu of other activities if funding is limited. For these projects, the ratio of sedimentation reduction benefit to implementation cost could be low.

IFI recommends that the Town and SBC first evaluate the contribution to the causeway shoal from road sand application, and also from the relatively higher potential sediment yield north shore watersheds. This would include an initial program of sediment coring of the shoal on lake side of the causeway, and possibly a follow-up engineering and hydraulic study. If the initial program concluded a plausible and likely contribution, then more in-depth evaluation of the actual watersheds along the north shore may lead to a more relevant, larger scale sediment reduction program in those watersheds. The Scoping Outline developed as part of this project will guide next steps in this evaluation. The long-term benefit of this approach may exceed that gained from the relatively small-scale culvert retrofit projects drafted as part of this study.

## *Literature Cited*

The analyses and findings for this project are found in the technical documents produced by IFI and are found in the appendices.

# *Appendix A*

IFI Technical Deliverables:

- SOW
- QAPP
- Task 2 Memo
- Task 3 Memo
- Scoping Outline
- Task 4 Memo
- Powerpoint presentation